Electronic Version
Stylesheet Version v1.1.1

Claims

[c1] 1.A method for making a metal surface-mount package comprising:
etching half-etched cavities into a mounting surface of a metal sheet substrate, the half-etched cavities reaching only partially and not completely through the metal sheet substrate to an opposite surface to the mounting surface;
filling the half-etched cavities with an insulator;
forming drilled vias within the half-etched cavities wherein side edges of the drilled vias are insulator and not metal, wherein bottoms of the drilled vias reach the metal sheet substrate;
forming a contact metal layer on the bottoms of the drilled vias;
filling the drilled vias with via metal;
forming and patterning metal over the via metal and over the mounting surface to form external metal pads on the mounting surface, the external metal pads electrically contacting the via metal and the contact metal layer;
forming inner cavities in the opposite surface that each reach the contact metal layer for at least two of the drilled vias filled with via metal;

placing conductive epoxy on the contact metal layer within the inner cavities;

placing a die onto the conductive epoxy, wherein electrodes on the die make contact with the conductive epoxy; and

sealing the die within the inner cavity by covering the inner cavity with a cover;

whereby the die is packaged in the metal surface-mount package with external metal pads on the mounting surface for surface mounting the metal surface-mount package to a printed-circuit board (PCB).

[c2] 2.The method of claim 1 wherein etching half-etched cavities further comprises depositing a resist layer onto the mounting surface, patterning the resist layer, developing the resist layer to form openings in the resist layer, and etching the metal sheet substrate through the openings in the resist layer to form the half-etched cavities.

[c3] 3.The method of claim 2 wherein the resist layer is a photo or radiation-sensitive layer.

[c4] 4.The method of claim 1 wherein forming drilled vias within the half-etched cavities comprises drilling with a mechanical drill or a with a laser, or etching.

[c5] 5.The method of claim 1 wherein filling the drilled vias with via metal comprises plating or depositing the via metal into the drilled vias.

[c6] 6.The method of claim 5 wherein the via metal is copper or a copper alloy.

[c7] 7.The method of claim 1 wherein forming and patterning metal over the via metal and over the mounting surface to form external metal pads on the mounting surface comprises attaching a metal foil to the mounting surface and patterning the metal foil to form the external metal pads.

[c8] 8.The metal surface-mount package made by the method of claim 1.

[c9] 9.The method of claim 1 wherein the cover is metal.

[c10] 10.The method of claim 1 wherein sealing the die comprises blowing relatively inert gas onto the die while the cover is being attached.

[c11] 11.The method of claim 10 wherein the relatively inert gas is nitrogen.

[c12] 12.The method of claim 1 wherein the metal sheet substrate is copper, a copper alloy, or a nickel-iron alloy.

[c13] 13.The method of claim 12 wherein forming the contact metal layer comprises forming a gold-nickel layer.

[c14] 14.The method of claim 12 wherein forming the contact metal layer comprises electro-plating a gold-nickel layer.

[c15] 15.The method of claim 1 further comprising:
separating the metal sheet substrate into a plurality of metal package bodies, each metal package body having an inner cavity sealing a die within, each die electrically connected to at least two of the external metal pads through at least two of the half-etched cavities filled with the via metal.

[c16] 16.The method of claim 1 wherein the die in the inner cavity is a crystal blank for an oscillator.

[c17] 17.The method of claim 16 further comprising:
curing the conductive epoxy after the die is placed onto the conductive epoxy.

[c18] 18.The method of claim 1 further comprising:
covering the mounting surface of the metal sheet substrate with an insulator after the half-etched cavities are formed,
whereby the external metal pads are separated from metal package bodies by the insulator.

[c19] 19.A manufacturing process comprising:

applying a first resist to a mounting surface of a metal sheet and patterning the first resist to form first openings to the metal sheet;

etching half-etched cavities in the first openings on the mounting surface of the metal sheet;

removing the first resist and applying an insulator onto the mounting surface so that the insulator fills the half-etched cavities to form filled cavities;

drilling holes within the half-etched cavities so that the holes are surrounded by the insulator but have a depth sufficient to reach metal under the filled cavities;

filling the holes with metal to form via-metal-filled holes;

applying a metal layer to the mounting surface and patterning the metal layer into external pads on the mounting surface, wherein the external pads connect to the via-metal-filled holes;

applying a second resist to a second surface opposite the mounting surface of the metal sheet and patterning the second resist to form second openings to the metal sheet;

etching die cavities that are larger than the half-etched cavities in the second openings on the second surface of the metal sheet;

wherein the die cavities are sufficiently deep to reach the metal in the via-metal-filled holes;

applying conductive epoxy into the die cavities in the second surface, the conductive epoxy placed onto the metal in the via-metal-filled holes exposed inside the die cavities;

placing die within the die cavities so that each die contacts at least two via-metal-filled holes through the conductive epoxy; and

sealing the die cavity and separating the metal sheet into metal packages that contain die in the die cavities, but are mounted to printed-circuit boards by the external pads on the mounting surface.

[c20] 20.An annular-shaped manufacturing process comprising:

applying a first resist to a mounting surface of a metal sheet and patterning the first resist to form first openings to the metal sheet;

etching half-etched cavities in the first openings on the mounting surface of the metal sheet;

removing the first resist and applying an insulator onto the mounting surface so that the insulator fills the half-etched cavities to form filled cavities;

wherein the half-etched cavities are annular shaped surrounding a metal island, and the metal island within the

annular shape forms via-metal-filled holes;

applying a metal layer to the mounting surface and patterning the metal layer into external pads on the mounting surface, wherein the external pads connect to the via-metal-filled holes;

applying a second resist to a second surface opposite the mounting surface of the metal sheet and patterning the second resist to form second openings to the metal sheet;

etching die cavities that are larger than the half-etched cavities in the second openings on the second surface of the metal sheet;

wherein the die cavities are sufficiently deep to reach the metal in the via-metal-filled holes;

applying conductive epoxy into the die cavities in the second surface, the conductive epoxy placed onto the metal in the via-metal-filled holes exposed inside the die cavities;

placing die within the die cavities so that each die contacts at least two via-metal-filled holes through the conductive epoxy; and

sealing the die cavity and separating the metal sheet into metal packages that contain die in the die cavities, but are mounted to printed-circuit boards by the external pads on the mounting surface.